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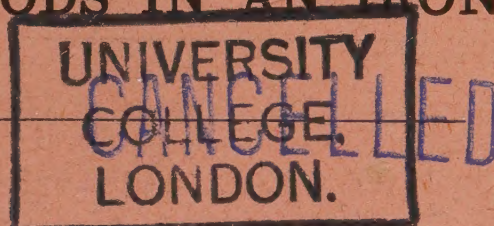
**DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL
RESEARCH.**

REPORTS

OF THE

INDUSTRIAL FATIGUE RESEARCH BOARD.

**No. 3. — A STUDY OF IMPROVED
METHODS IN AN IRON FOUNDRY.**



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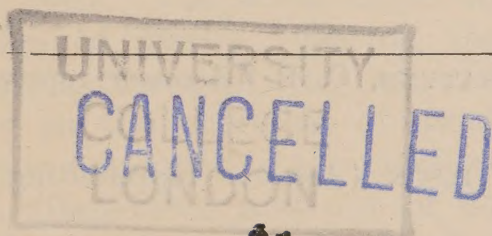
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PREFATORY NOTE

In December, 1917, the Secretary of State for Home Affairs invited the Department of Scientific and Industrial Research to appoint a Committee to investigate the subject of Industrial Fatigue on comprehensive and systematic lines, and a similar proposal was made by the Medical Research Committee.

A Research Board was accordingly appointed by the Department of Scientific and Industrial Research and the Medical Research Committee (now the Medical Research Council) jointly, with the following membership :—

C. S. SHERRINGTON, Sc.D., F.R.S. (Professor of Physiology, University of Oxford)—*Chairman*.

E. L. COLLIS, M.D. (Talbot Professor of Preventive Medicine, Cardiff).

WINIFRED CULLIS, D.Sc. (Professor of Physiology, University of London).

Sir WALTER FLETCHER, K.B.E., M.D., F.R.S. (Secretary, Medical Research Council).

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C. S. MYERS, C.B.E., M.D., F.R.S. (Director of the Psychological Laboratory, Cambridge).

MONA WILSON.

R. R. BANNATYNE, C. B. (*Assessor* representing the Home Office).

BERTRAM WILSON (*Assessor* representing the Ministry of Labour).

D. R. WILSON (H.M. Inspector of Factories)—*Secretary*.

Its terms of reference are :—" To consider and investigate the relations of the hours of labour and of other conditions of employment, including methods of work, to the production of fatigue, having regard both to industrial efficiency and to the preservation of health among the workers."

The duty of the Board is to initiate, organise and promote by research grants, or otherwise, investigations in different industries with a view to finding the most favourable hours of labour, spells of work, rest pauses, and other conditions applicable to the various processes according to the nature of the work and its demands on the worker. Reports embodying the results of these investigations will be issued from time to time.

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A STUDY OF IMPROVED METHODS IN AN IRON FOUNDRY.

By C. S. MYERS, M.D., Sc.D., F.R.S., Member of the Board.

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INTRODUCTION.

The following account is the result of a visit to the Derwent Foundry Co., Ltd., at Derby. The present Managing Director is Mr. Vincent Jobson, whose family have controlled the business uninterruptedly since the foundation of the firm by his great grandfather in 1801. The works cover an area of about $1\frac{1}{4}$ acres near the centre of Derby. During the war the number of employees in them increased from about 130 to 160. Only men were employed in the processes of moulding and casting, and only women were employed in the machine shops. The buildings are somewhat dilapidated and out of date, but the works are shortly to be moved to modern and far more commodious premises which are to be erected several miles beyond the town.

At the outset I wish to express my great obligation to Mr. Jobson and his staff for the courtesy and assistance I received during the conduct of my enquiries. Had it not been for Mr. Jobson's readiness to give me all the information in his power this report could not have been written. I also wish to point out that the principal object of this report is to determine to what extent output may be increased by movement study, shorter hours, &c., without involving greater fatigue. I have made no attempt to consider the wider social and economic effects of these factors.

In May 1915 the foundry first began to work for the Ministry of Munitions, since when it has, until the cessation of hostilities, been occupied in moulding and casting hand grenades and also in moulding, casting and machining what are known as fuse hole plugs. The Ministry estimated the capacity of the Derwent Foundry for these articles to be 3,000 weekly.

In August 1915 Mr. Jobson began to apply the methods described in this paper, and by August 1918 they had progressed so far as to be yielding an output capacity of over 20,000 plugs weekly. Even if this enormous difference in output be partly due to an original underestimate on the part of the Ministry of Munitions, the following comparisons testify to the value of Mr. Jobson's methods. He found that a firm he visited recently was pressed to turn out 5,000 plugs, whereas his own works, *with less plant* employed on the job, yielded an output equivalent to over 20,000 per week. Again, during the period August 1916-18, the value of the output from his works upon this particular job increased five-fold, although the price paid by the Ministry was meanwhile reduced by 13·3 per cent.

These results were obtained from a judicious combination of movement study, training of workers, improvements in appliances, shorter hours of work and higher wages.

Mr. Jobson's method of first approaching his employees was as follows :—"We are out," he told them, "for higher wages, less hours and more output. Will you help us? Are you willing to have your movements studied so that we can find out the best way, adopt this as standard and cut out useless and unproductive movements?" The men's consent having been obtained, the study of movements and the training were begun.

2. STUDY OF MOVEMENTS.

This was directed to :—

(a) Analysing the various jobs into their elemental units, studying each individual element with the assistance of a stop watch in order to arrive at the best method of performing it when all superfluous movements had been eliminated.

(b) Arranging the tools and materials employed in such a standard manner as to avoid unproductive movements.

(c) Establishing a standard set of movements for each process, together with a standard time for the performance of each.

(d) Combining such movements as could be performed simultaneously.

Mr. Jobson lays great stress upon the importance of obtaining the men's full consent and co-operation before anything in these directions can be satisfactorily begun.

When the movements had been finally standardised, a card of typewritten instructions was prepared for each job. This card contained a list of the standard movements necessary for each process, together with the times they should take to perform and it gave such details as whether the right or left hand should be used or both. The elemental times when added up at the foot gave the total time in which the whole job should be completed. This card was placed before each operator during the period of training.

The standard times of the various elemental units were all carefully catalogued so as to be available whenever new jobs involving a repetition of any of the elements already standardised might be under consideration. The number of elements standardised in the process of moulding alone ran into hundreds.

Mr. Jobson estimates that, in the case of moulding and casting, about 90 per cent. of the increase in output depended on improved efficiency on the "human" side, while in the machine shop the even greater increase in output was due largely, though by no means wholly, to improved efficiency of the lathes and tools.

3. TRAINING.

Of this 90 per cent. increase, the available data, as we shall see, indicate that over 20 per cent. is due to training. The methods and duration of training varied with the individual mentality of the different operators. Some needed constant and close supervision; others could be left largely to themselves. One of Mr. Jobson's most successful pupils was a man who could neither read nor write; but as he was able to commit to memory the instructions he received with astonishing ease and accuracy, he required only occasional supervision during training. Mr. Jobson lays great stress upon the fact that each operator must receive separate instruction, and he does not advocate the training of men in groups.

4. REDUCED HOURS OF WORK.

As soon as training was begun, the hours were reduced from 54 to 48 per week. Instead of starting work at 6.30 a.m. they began at 8 a.m. every morning, working until 5.45 at night, with an hour's interval from 12.30 to 1.30 for lunch, save on Saturday, when work ceased at 12.15. These hours were continued unchanged after the man had been trained.

5. SYSTEM OF PAYMENT.

During training each man was paid by day rate, his daily wage being raised to about 25 per cent. above the standard rate for the district. The daily output required was worked out by Mr. Jobson from the time study of the systematised elemental units. In all cases an allowance of 10 per cent. was made in favour of the operator so as to allow him approximately 45 minutes per day for personal needs, unavoidable delays, &c. The resultant output figure was known as the "Standard Output," and on it was based the piece price calculated so as to give the man a fair day's wage without the addition of the bonus as described below. Mr. Jobson found that the Standard Output was always beaten by men, and often by lads, after their training. Indeed, no one was considered to be finally trained until he had surpassed the Standard. When, during training, a man's output, based on the piece work scale, at length afforded him higher wages than he was receiving by day

rate, his pay was assessed on the higher scale.

Mr. Jobson holds that the man who produces a greater number of pieces is entitled to a higher price *per piece*, and with this object in view he originated his method of differential piece work which automatically adjusted the rates per piece paid to the men. As soon as a man's output reached 60 per cent. of Standard he began to receive a bonus. This bonus was an addition to his piece work earnings and consisted of an addition of 50 per cent. to all money the man had earned over and above a base rate of X pence per hour. To arrive at what a man would earn as bonus over and above his straight piece work earnings, suppose PR = his piece rate earnings in pence, H = hours worked, and X = the base rate equivalent to 60 per cent. of Standard; then the amount of bonus the man would get would be $\frac{PR - X}{2H}$. The price paid per piece thus rises auto-

matically with the increased output, and good timekeeping (to secure a higher hourly output) is encouraged. In the case of an adult and a lad whose wages I examined at random, the bonus amounted to 23 per cent. and 12 per cent. respectively in addition to the piece work payments they were receiving; or, in other words, the price per piece they received was raised 23 per cent. and 12 per cent. respectively over a man who only produced 60 per cent. of Standard.

The increase of earnings resulting from the method of payment may be appreciated from the following example. I examined the net piece work earnings of a certain worker for six consecutive weeks in 1915, before the new system was introduced, and for another six consecutive weeks in 1918. The increase in hourly earnings was within a decimal point of 200 per cent. It must be noted that war advances are omitted from the calculations absolutely and that the figures are based on *net* earnings.

Mr. Jobson lays great stress on the value of his special system of payment. After trial and rejection of various other systems he regards this as the fairest and most satisfactory, alike to employer and employee. He gave his workers an assurance that the piece rate once set would not be altered so long as the present methods of work continued unchanged.

6. INCREASED OUTPUT.

Data have already been given which indicate that the introduction of the new methods increased the output by more than 300 per cent. for jobs that include machine work. This is borne out by the following figures:—A job which before the war gave an average output of 48 per day of 10 hours was standardised under the new system at an output of 147 per day of $8\frac{3}{4}$ hours. This meant an increase in hourly output by nearly 284 per cent., an increase which was regularly surpassed by trained adult workers.

In another job, consisting only of moulding and casting and excluding machine work, the estimated output per day of 10

hours was 80 before organisation of material and training were begun. When the new system was being introduced a deputation of workers urged that 100 was the utmost to be expected from it. Nevertheless, profiting merely by the improved arrangement of their tools and materials, three workers, B, C and D, soon averaged 144, 151 and 143 respectively (over 36, 25 and $6\frac{1}{2}$ days respectively), C actually turning out 98 one Saturday before noon; whilst A, who had meanwhile been specially trained so as to eliminate needless movements, averaged 173 per day over 12 days. In contrast to B, C and D, who were more experienced workers, but had not been specially trained, A had only worked for 14 days before he began to receive training; he had previously been a bricklayer.

The results of A's training were as follows :—Before training he took 189 seconds to perform a certain job. The Standard time for this was 144·8 seconds. After two days' training A's time was reduced to 159 seconds, and after further training and practice he finally took 101·6 seconds to do the job. (These three values of A's work were averaged from 42, 35 and 48 repetitions respectively.) In other words, his efficiency improved after training and practice by 87·2 per cent.

The three more experienced workers, making full use of the improved organisation of material, but without special training, were found to fall short of the Standard time by 0·82 per cent. and to fall short of A's final time by 23·56 per cent. Moreover A easily beat, both in quantity and quality of output, certain experienced workers after they had received the same training. Mr. Jobson lays great stress upon the value of training men early in their work.

7. EFFECT ON THE WORKERS.

In applying the above described principles Mr. Jobson did not meet with any difficulty, save occasionally in the initial stages, when the men did not fully understand the system of payment and while they were endeavouring to overcome their prejudice against the acquisition of new and systematised movements. He was, however, always careful to point out that each worker was at any time free to return to the old method. "If you prefer the former system," he would say, "come to-morrow morning at half-past six, instead of at 8 o'clock, and return to your former wages." Some of the employees would have done so had it not been for the tact and persuasion exercised by Mr. Jobson and his works manager. Not one, however, actually returned to the old method. Mr. Jobson's relations with the Trade Unions have been amicable throughout.

At the present day the employees are perfectly contented. I separately interviewed 14 of them, chosen at random, and they were unanimous in their preference for the new system. Asked if they now felt more tired at the end of the day, with two exceptions they all replied that they felt less fatigue or found no difference. The exceptional cases were two men who had enor-

mously increased their output and who were doing much over Standard. Asked if they found the work under the present system more monotonous and uninteresting, with two exceptions they all replied in the negative. Indeed, three employees (two men and one woman) independently alluded of their own accord to the beneficial results of the abolition of idling, while another, a woman employed in the office, volunteered the experience that idling between jobs was no true rest compared with the ten minutes' pause now allowed the women in the middle of the morning. One man preferred the present system because it was more methodical and he was no longer worried by the foreman shifting him to different jobs. Another remarked on the better wages and characterised the present system as "best for yourself as well as best for the boss." The two employees who gave exceptional answers to the second question expressed a desire for variety of work, which had reference to the old as well as to the new method of working.

8. CONCLUSIONS.

From the foregoing it is clearly established that, in favourable circumstances, movement study, training and the organisation of material, combined with a specially devised system of payment, are capable of effecting an enormous increase of output with reduced hours of work. In the present instance this increased output, in conjunction with diminished cost of production, has been beneficial to the firm and has largely increased the wages of the employees. That a diminution, or at all events no increase, in fatigue is experienced by the workers despite the vastly greater output, clearly indicates that for equal output Mr. Jobson's methods have materially lessened the expenditure of energy put forth. How much of the increase in output and economy of effort is to be apportioned to systematic training, to organisation and improved efficiency of material, to shorter hours or to better food arising from higher wages, it is impossible to determine with greater accuracy than has been attempted. According to Mr. Jobson, these various factors are inextricably bound up with one another. Movement study must itself result in a better organisation and efficiency of material; and without the restful effects of shorter hours and the inducements offered by a better system of payment, movement study and training can have no chance of appreciable success. Mr. Jobson's experience is that movement study does away with all guessing, and he is of opinion that if the subject were taken up on a national basis it would go a long way towards solving much of the unrest now existing. He considers that at present neither the employer nor the workman knows sufficient about the possibilities of their respective "jobs."

May 1919.

